

NEW BENNETTITALEAN LEAVES FROM THE MESOZOIC OF EASTERN AUSTRALIA

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Abstract

Mesozoic bennettitalean leaves with strongly incurved pinna margins from the Walloon Series, Queensland, are described under the specific name *Otozamites incurvatus* n. sp., and another new form from the Tyers Group, Victoria, is described as *Otozamites boolensis* n. sp. Less well preserved Victorian specimens including *Ptilophyllum cutchense* Morris are also described.

Introduction

A variety of leaf remains from E. Australian Mesozoic sediments have been referred to the Bennettitales after examination of the external form, but anatomical and cuticular studies have been neglected. This is principally due to the fact that most collections consist of weathered outcrop material, but there is ample scope in nearly all Mesozoic areas for selective collections of more finely preserved specimens both from outcrop and mining localities.

Comparison with overseas forms on a morphological basis alone is difficult, and it is to facilitate this, and the correlation and dating of sediments that these Australian forms are described. The best preserved type is from the Walloon Series, Queensland, and the remainder from the Boola Boola Forest area, Victoria. Poorly preserved leaves from this latter area were described by the author (1962) under the names *Otozamites* sp. indet. and *Ptilophyllum?* sp. but the collection of more finely preserved material has allowed some expansion of these determinations.

Description of Types

CYCADOPHYTA

CYCADEOIDEALES

Otozamites incurvatus n. sp.

(Pl. XXXII, fig. 1-6; Pl. XXXIII, fig. 1-5; Pl. XXXVI, fig. 1; Fig. 1-3)

DIAGNOSIS: Pinnate leaf, maximum length preserved 40 mm and width 10-15 mm with pinnae arising from upper surface of rachis at about 45° and set well apart with strongly auriculate base. Pinnae falcate, or falcate-lanceolate, maximum length about 10 mm with lower margin upcurved to meet less strongly upcurved upper margin at an acutely pointed apex. Margins of pinnae strongly incurved, forming flaps directly protecting up to half of the morphological undersurface. Pinnae thick and somewhat coriaceous and attached at the centre of the base, with the upper auricle obscuring most of the rachis.

Venation of about 10 veins radiating from a central basal area and branching to the extremities, and represented on the upper surface by fine grooving.

SPECIMENS IDENTIFIED: Reg. No. Geological Survey of Victoria (GSV) 58874-58880. Holotype GSV 58878.

LOCALITY: Mine Dump, New Caledonia Coal Mine No. 2, near Rosewood, Queensland.

ROCK TYPE: Fine-grained light grey mudstone containing black carbonaceous plant remains, with interbedded coal bands.

COLLECTOR: Dr J. A. Townrow, Botany Department, University of Tasmania.

DATE: August 1961.

CUTICLE: Rachis—No distinction is evident between upper and lower cuticles. Both consist of rectangular-spindle shaped cells about $50\ \mu$ long by $20\ \mu$ broad, with strongly thickened longitudinal and transverse walls pitted to give a callus-like sinuous form to otherwise mildly undulating to straight cell walls. Stomata are absent.

Pinna Upper Surface—Cells with extremely heavily thickened and involute walls with lobe thickening reaching almost to the centre of the cell and occupying most of the lumen. Shape basically rectangular much modified by the wall sinuosity, and dimensions vary somewhat according to position on pinnae, but average about $48\ \mu$ long and $26\ \mu$ broad. Thickness is about $2.5\ \mu$. Stomata and papillae are absent.

Lower Surface—Lower surface of incurved segment—This is similar in thickness to that of the upper surface of the pinnae, but wall sinuosity is less extreme. The folds on the outer pinna margin and the inner edge of the overlapping flap are heavily cutinized.

Upper surface of incurved segment—This consists at the inner edge of involute walled cells with thickening diminishing from that seen on the lower surface, but near the outer extremity changes within 1-2 rows into cells with relatively unthickened walls. Papillae appear in this zone which is generally about one-third of the flap width from the inside margin, and possibly represents the stomata-free marginal zone found in the pinna lower cuticles of other bennettitaleans (cf. *O. boolensis* below). Less than halfway across the flap a fine fold represents the junction of this incurved segment or flap cuticle and that of the protected under-surface of the pinna. Treatment usually causes some contortion in this thin cuticle, but half the flap width appears to be the maximum distance for the position of the transition from flap cuticle to lower surface cuticle. That is, for at least half of its width the flap does not protect cuticular surfaces but provides a thicker lamina.

Lower surface covered by incurved segment and exposed lower surface—The extreme outermost cuticle protected by the flap is thin and tenuous and continues across the unprotected lower surface as vein and intervening cell areas. The former consist of elongated rectangular shaped cells with wall sinuosity less marked than on the upper pinnac surface and bearing short subcircular papillae with outer diameter about $20\ \mu$ and inner less than half this figure. The intervening areas also consist of involute walled cells the shape of which are modified by the presence of numerous stomata aligned at right angles to the vein cells. The intervening or stomatal cell areas are generally (depending upon location in respect to major veins, etc.) 3 times as wide as the vein areas which are seldom more than 4 cells wide. Stomata appear to lie in rows within the stomatal areas, the rows being separated by narrow stomatal-free bands of cells which may represent the position of minor veins. There are on average 100 stomata per sq. mm of exposed lower surface cuticle.

Hollow papillae also occur in the intervening areas, where nearly all cells are

papillate. Wall thickening is less prominent than on the upper surface except for portions of the specialized cells around the stomatal openings. Stomata are not deeply sunken, and are of typical bennettitalean form with cutinized guard cells ($36-48 \times 12-16 \mu$) surrounded by two hemispherical involute walled subsidiary cells ($48-67 \times 17-22 \mu$). The guard cells are thickened around the stomatal slit as illustrated in Pl. XXXVI, fig. 1.

REMARKS: The following bennettitaleans from the Walloon Series are recorded by Walkom (1917):

Ptilophyllum (Williamsonia) pecten (Phillips)

Otozamites queenslandi Walkom

Otozamites obtusus Lindley and Hutton

Otozamites Feismanteli Zigno

Otozamites cf. Mandelslohi Kurr.

Of these *P. (Williamsonia) pecten*, and *Otozamites feismanteli* correspond best in pinna size, but reference to Table 1 below, which also includes pertinent overseas forms for comparison, shows no form with the same pinna characteristics as *O. incurvatus*. *Otozamites bechei* types, e.g. *O. linearis* (Halle 1915, from Graham Land), appear to compare best on this form basis.

TABLE 1

Comparison of *O. incurvatus* with Queensland and overseas bennettitaleans on the basis of pinna forms

| Species | Pinna characteristics | | | | |
|---|-------------------------------------|---|--|--------------------------|------------------------------|
| | Size | Shape | Arrangement | Xeromorphic modification | Venation |
| <i>O. incurvatus</i> n. sp. | length up to 10 mm | falcate-falcate lanceolate, base strongly auriculate | well space at about 45° to rachis | incurved margins | about 10 veins at base |
| <i>P. (Will.) pecten</i> (Phillips) (Queensland specimens) | length 10 mm | long, narrow, very slight auriculation | closely set at wide angle to rachis | — | 4 per pinna |
| <i>P. pecten</i> (Phillips) (Yorkshire specimens) | length less than 10 mm | lanccolate | crowded at wide angle to rachis | lamina thick | — |
| <i>O. feismanteli</i> Zigno (Queensland specimens) | length 12 mm | linear, auriculate | overlapping almost at right angles to rachis | — | 6-8 at base |
| <i>O. linearis</i> Halle | length average about 12 mm | lanceolate to oblong falcate | distant, rarely closely set | — | dense, bifurcating |

Overseas forms with incurved pinna margins include the bennettitalean, *Pseudocycas roemeri* (Schenk) Holden (Halle 1915), and the unrelated *Cycadopteris anglica*, described by Townrow and Hancock in 1961. Other forms with extremely thick lamina, e.g. *P. pecten*, also show some tendency to incurving of margins.

A type figured by Saporta (1875) as *O. marginatus*, with a purported marginal pinna fold was later classified by Seward (1900) as *O. beani* Lindley and Hutton. Previously (1895) Seward had regarded this somewhat fragmentary specimen as possibly an immature specimen of *O. klipsteinii* Dunker. In any case, *O. marginatus* bears no other resemblance to the Walloon specimens. That the pinna margin of these latter is incurved with an underflap, and not merely swollen and recurved, is readily established by coarse sectioning of the pinna, where two distinct lamina sections may be seen closely appressed, but definitely free, apart from the folded marginal section (see Fig. 3).

Fig. 2 shows the large degree of protection afforded the undersurface of the pinnae by the incurved margin. When it is realized that the incurved portion actually consists of two adjacent surfaces physiologically acting in part at least as lower surfaces, the proportion of leaf surface directly protected by the flap increases a great deal, and averages about 50% over the entire lamina.

This xeromorphic adaption of incurved pinnae margin, not unusual in bennettitaleans of the *Otozamites* and *Ptilophyllum* type (see above), is more spectacularly developed in *O. incurvatus*, and is only one type of drought resistant modification illustrated in other forms by papillae 'mats', thickening of lamina, sunken stomata, etc.

On the basis of cuticular comparison the specimens compare best with *Ptilophyllum distanse* Feistmantel and *P. acutifolium* Morris from the Upper Jurassic of India (Jacob and Jacob 1954). The cuticles of both these however, can be readily distinguished from *O. incurvatus* (see Table 2).

TABLE 2
Comparison of O. incurvatus with overseas forms on the basis of pinna cuticle anatomy

| Species | Upper cuticle | Lower cuticle | | | |
|-----------------------------------|--------------------------------|-------------------------|------------------------------------|--------------------|----------------------|
| | | Papillae | Vein areas | Stomata frequency | Subsidiary-cell |
| <i>O. incurvatus</i> n. sp. | resistant and highly cutinized | circular, prominent | about 4 cells wide | 100 per sq. mm | outer walls sinuous |
| <i>P. acutifolium</i> Morris | extremely delicate | oblong and circular | 2-4 cells wide | 175-200 per sq. mm | outer walls sinuous |
| <i>P. distanse</i> Feistmantel | delicate | circular, not prominent | 4-5 cells wide | 120-125 per sq. mm | outer walls sinuous |
| <i>P. pecten</i> Phillips | persistent | very prominent, in rows | narrower than <i>O. incurvatus</i> | — | outer walls straight |

Note: Only the most pertinent and closely comparable species are included for comparison and certain peculiarities, particularly in stomatal construction, of each species are ignored in favour of features in common.

As no previously determined form has the same combination of pinna form and cuticular properties, it is evident that new specific nomenclature is required. The principal problem is whether to include the species under the genus *Otozamites* or *Ptilophyllum*. The former has been chosen on the basis of pinnac form distinctions recapitulated by Harris (1949). Harris here also tentatively postulates a basic cuticular structure which would possibly place the species in *Ptilophyllum*, but until

generic classification on anatomical remains is established as a general practice, the more practicable classification on general form will be adhered to.

A new species *Otozamites incurvatus* is thus instituted.

The cuticle of this species is very beautifully preserved, and, apart from the

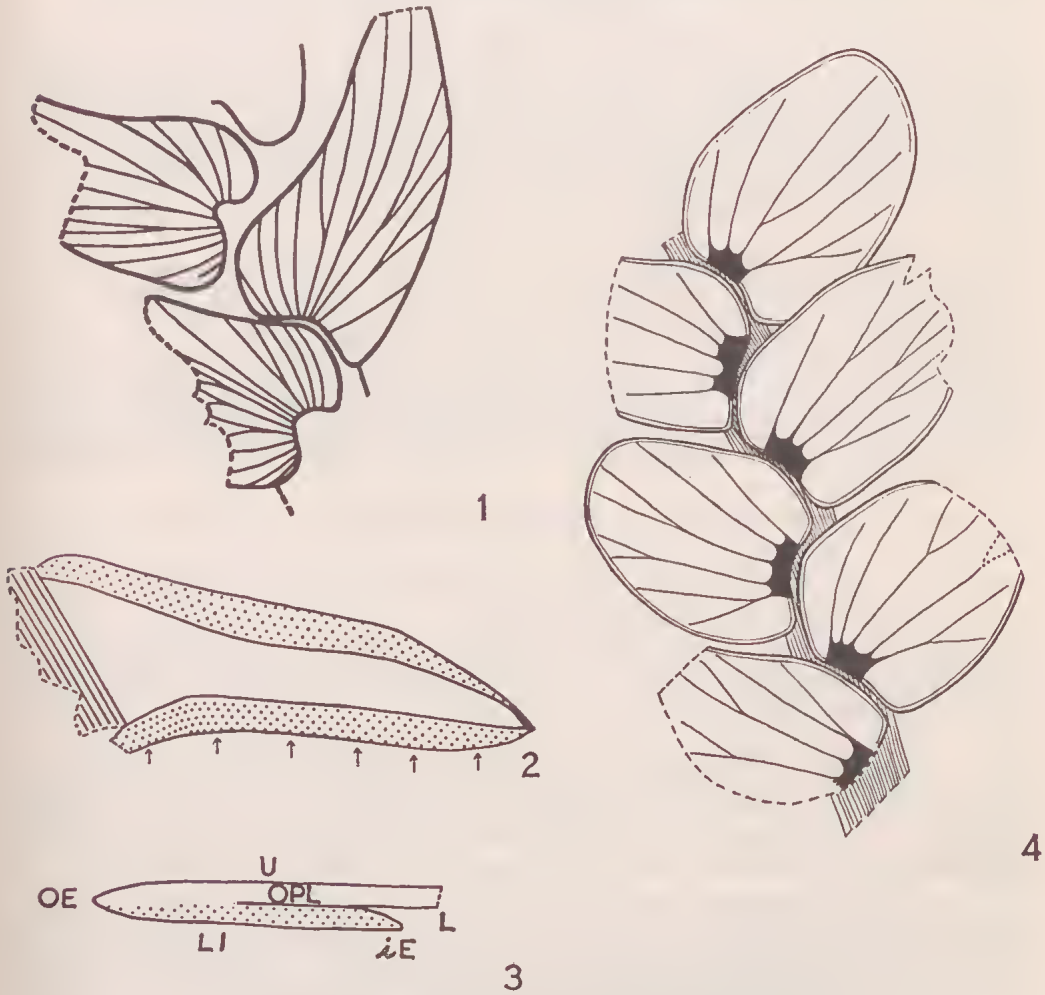


FIG. 1-3—*Otozamites incurvatus* n. sp. Line drawings.

(1) Portion of leaf showing pinna arrangement and venation, upper surface.

× c. 7.

(2) Pinna, lower surface, with incurved portion dotted. × c. 7. Rachis represented by parallel lines. Arrows reading from left (or pinna base) indicate where 36%, 51%, 58%, 55%, 56% and 54% respectively of the pinna lower surface is covered by the incurved segment.

(3) Diagrammatic section through edge of pinnae showing flap-like nature of incurved area. × c. 100. For explanation of lettering see 'Explanation of Plates' Pl. XXXII, fig. 4.

FIG. 4—*Otozamites boolensis* n. sp. Line drawing. Portion of leaf showing pinna arrangement and venation, upper surface. × 10.

difficulty of separating adhering layers in the incurved flap region, is readily prepared and mounted using standard oxidation—ammonia techniques.

Otozamites boolensis n. sp.

(Pl. XXXIV, fig. 1-6, 8; Pl. XXXV, fig. 3, 7; Pl. XXXVI, fig. 2, 3; Fig. 4)

DIAGNOSIS: Pinnate leaf, maximum length preserved 55 mm with pinnæ arising from upper surface of rachis at an angle generally less than a right angle, and attached at a central basal callosity between two slight auriculations. Pinnæ shape oval to oval-falcate also varying according to position on the leaf, the former more characteristic. Lower pinna margin strongly recurved towards the apex, sweeping up to meet a recurving upper margin in a blunt or slightly extended tip. Both margins slightly thickened. Average pinna length 3 mm. Average width at widest section 2 mm.

LOCALITY: Rintoul's Ck, Boola Boola Forest, SE. Victoria. Locality No. 23 Coordinates Misc. Topo. 83 sheet 4, 3011 N, 4473 E. Tyers R., Boola Boola Forest, precise locality unknown (see Reg. No. 1420 below).

SPECIMENS IDENTIFIED: Reg. No. GSV 58781 (holotype), 58780, 58782, 58783, 58784, 58785, 58786, 58789, 59045 (counterpart), 59028, 59029, 59033, 59034, 59035, 59036, 59037, 59038, 59039, 59040, 59041, 59042, 59043, 59045, 59046, 59047. Reg. No. Geology Dept University of Melbourne 1420 '*Thinnfeldia australis* Morris'.

ROCK TYPE: Hard grey-blue mudstone, with black or sepia coloured plant remains.

COLLECTOR: Author (except University specimen).

DATE: November 1958 and August 1962.

CUTICLE: Rachis—Upper and lower cuticles appear to be similar and consist of relatively straight walled rectangular-spindle shaped cells 40-50 μ long and 20 μ broad with walls thickened.

Pinna—Upper Surface—The upper cuticle consists of rectangular-sub-rectangular shaped cells with sinuous walls thickened to a moderate degree at the lobes and saddles. This cuticle appears to be thinner than the lower and usually disintegrates during maceration, but this effect may be due to the absence of any thickening or support in the nature of papillae or hairs. Stomata are also absent.

Lower cuticle—This consists of rows of stomata free, sinuous walled, square-polygonal shaped cells about 10 wide around the pinna margin, with bands of rectangular shaped cells possibly representing vein courses. These cells do not bear papillae or hairs and thickening on the lobes and saddles of the walls is minor.

Stomata are sunken and arranged (Pl. XXXIV, fig. 6) transversely across the long axis of the pinna, apparently haphazardly and closely crowded (averaging 170 per sq. mm) but closer examination shows that distribution reflects vein position and divergence. Size varies from 28-36 \times 43-54 μ . The ordinary epidermal cells bear hollow papillae. The stomata are of typical bennettitalean form and have thickened guard cells. The hemispherical subsidiary cells have finely granular non-sinuous outer walls and in some instances bear small flat papillae not evident in either of the two stomata figured (Pl. XXXVI, fig. 2, 3).

REMARKS: The cuticles of this form are not as well preserved as those of *O. incurvatus* described above, but on careful maceration yield cuticles from both

pinna surfaces. The sub-ovate pinna shape of *O. boolensis* can be the basis for comparison with some species, e.g. *O. bunburyensis* Zigno (this latter also has strong xeromorphic adaptations with thickened margin and thick hair cover on the pinna lower surface), but the combination of pinna shape and venation characteristics is unique. On morphological grounds the specimen readily falls into the *Otozamites* category. On cuticular details however, the species perhaps has closer affinity to *Ptilophyllum* on the basis suggested by Harris (1949) of papillae on the subsidiary cells overhanging the guard cells. Some of the Indian *Ptilophyllum* species described by Jacob and Jacob (1954) also have somewhat similar cuticles. *P. indicum* Sahni and Sahni seems to perhaps be the closest comparable form, with a similar stomatal density, but the cuticle on the lower surface of the pinna is more strongly defined into stomatal and non-stomatal areas, and pinna form differs.

***Otozamites* sp. indet.**

1962 *Otozamites* sp. indet. Douglas p. 41, Fig. 1; Pl. 7, fig. 1. Specimens identified. Reg. No. GSV 57747, 57748 (counterpart).

REMARKS: The venation characteristics of this specimen (see Douglas 1962, Fig. 1; Pl. 7, fig. 1) are somewhat similar to that of Indian forms of *Ptilophyllum cutchense*, which species is cofossilized at Boola Boola in Loc. 1 (see below). However, leaf size of GSV 57747 is larger than that of *P. cutchense* from this locality and the upper auricle at the pinna base is more persistent and pronounced, hence an *Otozamites* determination is retained.

***Ptilophyllum cutchense* Morris**

(Pl. XXXIV, fig. 7; Pl. XXXV, fig. 1, 2, 4-6; Pl. XXXVI, fig. 4)

1962 *Ptilophyllum?* sp. Douglas p. 43, Pl. 7, fig. 5.

1962 *Otozamites* sp. indet. Douglas p. 41, Pl. 7, fig. 2, 3, 4.

SPECIMENS IDENTIFIED: Reg. No. GSV 53603, 53605 Kadnook (near Coleraine), Western Victoria; 57745, 57746, 57749?, 57750, 57757-1,* 57775, 57776, 57777, 57779, 57780, 57781, 57785, 57786, 57787, 57788, 57790, 57793, 57794, 57796-1-2-3, Boola Boola Forest area (Douglas 1962 Loc. No. 1); 57783,* 57784,* Boola Boola Forest area (Douglas 1962 Loc. No. 27); 59019,* 59020, 59021,* 59022, 59023 (Counterpart) 59024, 59025, 59026, 59027 (Counterpart) Boola Boola Forest area Loc. 28 Coords. Misc. Topo. 83 sheet 5, 3025 N, 4497 E; 59056 Locality unknown (see below).

REMARKS: Pinna shape and angle of insertion on the rachis vary a good deal in these specimens, but the majority of Boola Boola Loc. 1 bennettitalean specimens are now classified in this species. These include Reg. No. 57745 and 57750 formerly (Douglas 1962) called *Otozamites* sp. indet. These are now included in *P. cutchense* because of the lack of prominent auricles on the pinna base, similar pinna and venation form to *P. cutchense*, and in particular the nearby fossilization of similar leaves yielding *P. cutchense* type cuticles. Most of the best preserved cuticle was obtained from Loc. 28 specimens, the stratigraphical position of which in respect to Loc. 1 is not clear, but which appears to be younger. Morphologically however, they are similar. No specimens were found with pinna upper and lower surface cuticles completely preserved.

Some specimens (indicated in list above by asterisk) with pinnae set a little apart, differ from the majority of Indian *P. cutchense* specimens, but examination of cuticles from Boola Loc. 28 specimens of this type show that the structure agrees with the Indian material as far as can be ascertained from the relatively poorly preserved leaves.

Rachis cells are rectangular with thickened and pitted walls. The upper cuticle is thin and tenuous, but fragments were obtained containing square-rectangular cells with sinuous walls thickened on the lobes and saddles.

The lower cuticle bears sinuous walled cells with very wide hollow papillae, a feature characteristic of the Indian form. Stomata are transversely orientated, and in rows, averaging 120 per sq. mm with vein cells indistinguishable. Size is from $15-18 \times 22-30 \mu$. A stomata-free region runs around the margin of the pinna, but narrows near the base. The subsidiary cells have straight outer walls, with a granular texture. The outer walls of the guard cells are also prominent.

The upper surface cuticles of the pinna of both *O. boolensis* and *P. cutchense* are very similar, and difficult to distinguish, and both lower surface cuticles show similarity in differentiation into wide marginal stomata free zones. However, the lower surface cuticles may readily be distinguished by the alignment of *P. cutchense* stomata in more definite rows, the smaller stomatal concentration per unit area in this species, and the absence of small projecting papillae around the stomata. The narrow pinnae of *P. cutchense* are easily distinguished from the ovate pinnae of *O. boolensis* in hand specimen.

P. cutchense is widely dispersed in Victoria, as it has been collected from the far west of the State (Kadnook) and although absent from nearly all horizons perhaps is also present in certain restricted occurrences in the basal part of the sequence in the South Gippsland Strezlecki Group non marine Mesozoic sediments, as the specimen identified from an unknown locality (Reg. No. 59056) was stored in company with fossils from this area. *Ptilophyllum* is not present in the well collected upper part of the sequence in the Strezlecki Group. *O. boolensis* is not found in fossil Loc. 1 in the Boola Boola forest area, but is present at Loc. 23 in this same district. *P. cutchense*, most prolific at Loc. 1, has not been found at Loc. 23. This restriction of both types to different beds appears to be due to peculiarities of deposition rather than appreciable difference in geological age, as the *O. boolensis* locality although stratigraphically lower than any of the Boola Boola *P. cutchense* beds, does not appear to be separated by any radical change in sedimentation.

Although described for convenience under two names, *Otozamites* and *Ptilophyllum* the bennettitalean remains described from Boola Boola however, do fall into a natural group and, I think, probably are derived from one natural genus, the distinction in classification being retained to follow the taxonomic procedure generally followed at present.

AGE OF SEDIMENTS: (i) *O. incurvatus* beds. De Jersey (1960) regards the Walloon Coal Measures in the type area as Lower Jurassic on the basis of comparison with Western Australian microfloras.

(ii) Boola Boola forest Mesozoic beds. The beds in the Boola Boola forest area from which the *O. boolensis* specimens (Loc. 23) are derived are thin persistent laminations of mudstone reaching a maximum thickness locally of 2 ft, but usually of less than 6 in., between massive sandstones resting some 100 ft above very coarse grained basal conglomerates. These mudstones are stratigraphically below the coarse mudstones and fine sandstones containing the *P. cutchense* specimens (Loc. 1, 27 and 28). This basal section of the Victorian non marine Mesozoic called 'Tycers Group' (Philip 1958), is regarded by Dettmann (1963) on microfloral evidence, as Lower Cretaceous in age. This follows similar, but tentative datings in Cookson and Dettmann (1958) and Dettmann (1959).

Although portion of the Indian sequence containing *P. cutchense* appears to be Upper Jurassic in age, Evans (1961) also presents microfloral evidence for a Lower Cretaceous age of much of the Merino Group sediments which have yielded this species at Kadnook.

Certain of the floral elements in other basal beds at Boola Boola stratigraphically between Loc. 1 and 28 (e.g. *Rienitsia?* sp., Douglas 1963) have strong pre-Cretaceous affinities, but the general aspect of the flora is strongly 'Wealden', and in the absence of evidence to the contrary a dating of 'basal Lower Cretaceous' must be assigned to the Boola Boola floras described.

Acknowledgement

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Explanation of Plates

PLATE XXXII

Otozamites incurvatus n. sp.

Fig. 1—Reg. No. 58878 (Holotype) $\times 3$.

Fig. 2—Reg. No. 58878 (Holotype) showing pinna base and traces of venation $\times c. 13$.

Fig. 3—Reg. No. 58879 $\times 3$.

Fig. 4—Slide No. 3302 $\times c. 40$. Pinna cuticles after treatment, unfolded (except OPL see below), and described as follows: U = Upper surface of pinna; OE = Outside edge of pinna; LI = Lower surface of incurved segment of pinna; iE = Inside edge of incurved segment of pinna; OPL = Adhering cuticles. (a) pinna under-surface covered by flap, (b) upper surface of incurved segment, (c) portion of lower surface of incurved

segment. A diagrammatical section through pinna showing area of derivation of tissues indicated above is shown in Fig. 3.

Fig. 5—Slide No. 3144 \times c. 520. Rachis cuticle showing thickened and pitted cell walls.

Fig. 6—Slide No. 3146 \times c. 520. Cuticle from lower surface of incurved segment of pinna, designated LI in fig. 4 above.

PLATE XXXIII

Otozamites incurvatus n. sp.

Fig. 1—Slide No. 3143 \times c. 520. Cuticle from upper surface of pinna.

Fig. 2—Slide No. 3302 \times c. 115. Cuticle from relatively unprotected lower surface of pinna (see L fig. 6 above) showing arrangement of stomatal and intervening areas.

Fig. 3—Slide No. 3302 \times c. 520. Cuticle from relatively unprotected lower surface of pinna showing stomatal area.

Fig. 4—Slide No. 3302 \times c. 520. Cuticle from relatively unprotected lower surface of pinna (see L fig. 6 above) showing intervening (non-stomatal) area, with rectangular papillated vein cells.

Fig. 5—Lower surface of pinna showing incurved flaps, on either side of partially macerated pinna. \times c. 25.

PLATE XXXIV

Fig. 1-6, 8—*Otozamites boolensis* n. sp.

Fig. 1—Reg. No. 59036 \times 6. Pinna from large leaf with traces of veins remaining.

Fig. 2—Reg. No. 59047 \times 3. Atypical leaves. Pinna shape and arrangement vary somewhat from holotype (see fig. 4 below) but venation, size, and associated specimens correspond with holotype.

Fig. 3—Slide No. 3112 \times c. 25. Pinna after partial maceration.

Fig. 4—Reg. No. 58781 (holotype) \times 3.

Fig. 5—Reg. No. 58789 \times 3.

Fig. 6—Slide No. 3111 \times c. 40. Pinna after maceration with upper and lower cuticles adhering, and showing stomatal distribution in lower cuticle.

Fig. 8—Slide No. 3107 \times c. 520. Rachis cuticle.

Fig. 7—*Ptilophyllum cutchense* Morris. Slide No. 3380 \times c. 40. Stomata arrangement, lower pinna surface. Pinna oriented with base at top of plate.

PLATE XXXV

Fig. 1—*Ptilophyllum cutchense* Morris Reg. No. 59027. \times 3. Selected pinnae outlined for clarity.

Fig. 2—Slide No. 3380. Cuticle from lower surface of pinna showing cells from marginal stomata free zone. \times c. 520.

Fig. 3—*Otozamites boolensis* n. sp. Slide No. 3470 (from holotype). Cuticle from lower surface of pinna showing stomata, and outer stomata free zone. \times c. 115.

Fig. 4—*Ptilophyllum cutchense* Morris Slide No. 3325. Rachis cuticle \times c. 520.

Fig. 5—Slide No. 3325. Cuticle from upper surface of pinna showing thickening on lobes and saddles. \times c. 520.

Fig. 6—Slide No. 3324. Cuticle from lower surface of pinna showing stomata and associated cells with large hollow papillae. \times c. 520.

Fig. 7—*Otozamites boolensis* n. sp. Slide No. 3470 (from holotype). Stomata, lower surface of pinna. \times c. 520.

PLATE XXXVI

Fig. 1—*Otozamites incurvatus* n. sp. Slide No. 3288. Stoma \times c. 1200, lower surface of pinna. Portion outlined to diagrammatically illustrate papillae (P), outer wall of guard cell (OWG), sinuous outer wall of subsidiary cell (OS), and thickening of guard cell (T).

Fig. 2—*Otozamites boolensis* n. sp. Slide No. 3328. Stoma \times c. 1200, lower surface of pinna. Portion outlined to diagrammatically illustrate papillae (P), outer wall of guard cell (OWG), possible position of outer wall of subsidiary cell (OS?), and possible position of inner wall of subsidiary cell (IS?).

Fig. 3—*Otozamites boolensis* n. sp. Slide No. 3328. Stoma \times c. 1200, lower surface of pinna. Portion outlined to diagrammatically illustrate possible papillae (P?), outer wall of guard cell (OWG), outer wall of subsidiary cell (OS), and subsidiary cell (S).

Fig. 4—*Ptilophyllum cutchense* Morris Slide No. 3324. Stoma \times c. 1200, lower surface of pinna. Portion outlined to diagrammatically illustrate broad papillae (P), obscure outline of epidermal cells (E), guard cell (G), and outer wall of subsidiary cell (OS).